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Bedford, MA

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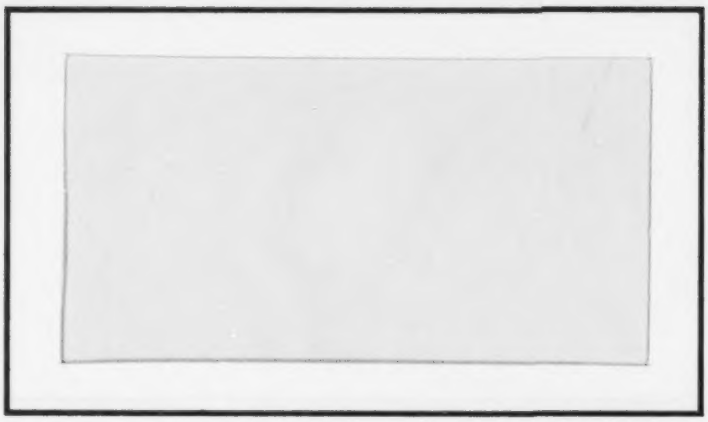

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The reduction in sulfur content varied from 0 to 57 percent by weight while the reduction in ash content varied from 10 to 85 percent by weight. These values are well within the range of results previously reported in the literature.

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Final Report

August 1982

Prepared by

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SECTION 1

INTRODUCTION

In order for the U.S. EPA to more readily evaluate the adequacy of coal preparation plans proposed by companies with coal burning operations, the following tasks were undertaken by GCA to provide EPA with a ready reference on coal cleaning for emission control in the United States:

- Identify coal cleaning plants with a raw coal capacity of 500 ton/hr or greater
- Specify the type of equipment used at each plant
- Specify the type of coal washed, principal application(s) of coal, and the ash and sulfur content in the raw and cleaned coal for a limited number of plants
- Provide a typical construction schedule including milestones and cost analysis for a 600 ton/hr capacity plant
- Include a discussion of the various types of coal cleaning techniques, equipment used and their purpose.

PROJECT APPROACH

The 1981 Coal Mine Directory, published by McGraw-Hill, Inc.,[1] was utilized to identify coal cleaning plants, specify the type of equipment used and to determine the daily capacity. Determination of the hourly capacity (ton/hr) required more investigation. After discussions with several preparation plant managers, it was evident that dividing the daily capacity by 8 hours times the number of shifts, when given in the Coal Mine Directory, was not a reliable indication of the hourly capacity. Therefore, other criteria were devised following a discussion with a coal preparation plant manager.[2]

Assuming yearly operation of plants to be 230 days (taking into consideration 5 day work weeks, holidays, strikes, etc.) and daily operation of 14 hours, gives a yearly total of 3220 hours of operation. By dividing the annual tonnage figures by this number it was concluded that annual production of 1,500,000 tons of coal or greater at the mine, could adequately satisfy the raw coal demands of approximately a 500 ton/hr coal cleaning plant. Values similar to these are reported in "Cost, Energy, and Environmental Sensitivity Analysis of Coal Cleaning Technology for Industrial Boiler Applications."[3]

The authors used values of 250 operating days per year and 13.3 hours of daily operation resulting in a total of 3325 hours of operation annually. Plants where the above determinations could not be used were contacted and the hourly capacities obtained from the Preparation Managers. Also, "Chronology of Coal Preparation Plants and Handling Systems built by McNally Pittsburgh Inc. 1921-1981"[4] was utilized in some instances to identify the rated hourly capacity of plants.

Data on the type of coal(s) washed was obtained from Keystone's U.S. Coal Mine Production By Seam-1976[5] and Perry's Handbook.[6] General information on construction schedules and milestones was obtained from various contractors as well as from plant managers. Costs were extracted from Cost, Energy, and Environmental Sensitivity Analysis of Coal Cleaning Technology for Industrial Boiler Application[3] which contains designs, costs, environmental and energy factors for 13 physical coal cleaning plants designed for 11 selected U.S. coals.

SECTION 2

INDUSTRY DESCRIPTION

CONVENTIONAL PHYSICAL COAL CLEANING

Physical coal cleaning is a proven technology for upgrading raw coal by physical removal of associated impurities. There are over 450 physical coal cleaning plants located in the U.S. handling over 400 million tons of raw coal per year. The commercial practice of coal cleaning is currently limited to the gravity methods together with minor application of the froth flotation methods. Jigging still handles the largest portion of coal cleaning, but dense-medium processes and concentrating tables are becoming more popular; froth flotation is starting to play an important role.[8]

The effectiveness of physical coal cleaning depends on the type of sulfur. The following discussion from Assessment of Coal Technology: First Annual Report[8] (McCandless, L. C. and R. B. Shaver) describes the types of sulfur found in coal and the best removal strategy.

There are three general forms of sulfur found in coal: organic, pyritic, and sulfate sulfur. Sulfate sulfur is present in the smallest amount (0.1 percent by weight or less). The sulfate sulfur is usually water soluble, originating from in-situ pyrite oxidation and can be removed by washing the coal. Mineral sulfur occurs in either of the two dimorphous forms of ferrous disulfide (FeS_2)--pyrite or marcasite. The two minerals have the same chemical composition, but have different crystalline forms. Sulfide sulfur occurs as individual particles (0.1 to 25 cm in diameter) distributed through the coal matrix. Pyrite is a dense mineral (4.5 g /cm^3) compared with bituminous coal (1.30 g /cm^3); and is quite water-insoluble, thus the best physical means of removal is by specific gravity separation. The organic sulfur is chemically bonded to the organic carbon of the coal; and cannot be removed unless the chemical bonds are broken. The amount of organic sulfur present, defines the lowest limit to which a coal can be cleaned with respect to sulfur removal by physical methods. Chemical coal cleaning processes, currently in the developmental stage, are designed to attack and remove up to 40 percent of organic sulfur.[8]

The various physical cleaning processes employed are based upon physical or physical-chemical differences between coal and its associated impurities. Physical cleaning is capable of removing, on the average, about 50 percent of the pyritic sulfur and 30 percent of total sulfur. The result depends on the washability of coal, unit processes employed, and separating density.[9]

PROCESS INFORMATION

Much literature has already been published describing coal preparation processes as well as types of equipment utilized. The following discussion taken from Environmental Assessment of Coal Cleaning Processes: First Annual Report; Volume 1. Executive Summary[7] (Lemmon, A. W., et al. June 1979) concisely describes current practices.

The principal coal cleaning processes used today are oriented toward product standardization and ash reduction, with increased attention being given to sulfur reduction. Coal preparation in commercial practice is currently limited to physical processes. In a modern coal cleaning plant, the coal is typically subjected to (1) size reduction and screening, (2) separation of coal from its impurities, and (3) dewatering and drying.[7]

In a modern coal cleaning plant, the crushed coal is often divided into coarse, intermediate, and fine sizes; and separation of ash and pyrite from the coal is then accomplished with a variety of devices for the three individual size groupings. In coarse coal circuits, the coal is cleaned with one or a combination of gravity separation devices such as jigs, launders, or heavy-medium vessels. The intermediate-size coals are usually cleaned with concentration tables or heavy-medium cyclones. In cleaning of fine-size coal, froth flotation or hydrocyclones are often employed. Following the wet cleaning process, the product requires dewatering or complete drying depending on the ultimate use and transporation systems being utilized.[7]

As a result of water pollution regulations and the coal industry's desire to improve fine coal recovery, recirculation and treatment of wash water are integral parts of the operation of a modern coal cleaning plant. In particular, closed water circuits have grown in popularity because they eliminate discharge to streams, reduce make-up water, and allow for recovery of coal. Since closing the circuit results in the build-up of slimes, it is necessary to remove a certain portion of these fine solids. Standard equipment generally applied in a closed water circuit consists of thickeners, cyclones, filters, and/or solid bowl centrifuges.

The disposal of coal cleaning plant waste is a worldwide problem of increasing magnitude. Coal refuse consists of waste coal, slate, carbonaceous and pyritic shales, and clay associated with a coal seam. It is estimated that about 25 percent of the raw coal mined is disposed as waste. Coal refuse disposal involves two quite separate and distinct materials--a coarse refuse (+28 mesh) and a fine refuse (-28 mesh). The coarse refuse is normally disposed in an embankment by dumping either from an aerial tramway or from trucks. The fine refuse is normally removed from the preparation plant water circuit as a thickener underflow and impounded into nearby settling ponds.[7]

Transportation of coal from the mines or preparation plants to the point of consumption is one of the most important factors affecting coal utilization because transportation costs frequently account for between one-third and one-half of the delivered price of coal. In conjunction with transportation

and storage of coal, a wide variety of materials handling operations is needed. These include loading and unloading, stacking and reclaiming, and transferring coal in a plant. As the amounts of coal to be handled have grown, the material systems have become more mechanized and equipped with more automatic and integrated control devices.[7]

Table 1 summarizes physical coal cleaning unit operations and their application to removal of sulfur.[8]

Figure 1 presents a schematic of a physical coal cleaning plant capable of cleaning coarse, medium and fine coal.[8] Flow and unit operations necessary for the treatment of various size coals are depicted.

It is not possible to categorize the sulfur content by the size of the cleaned coal. As previously described, the three sulfur forms can be removed by various methods. The sulfate sulfur by washing, pyrite sulfur by specific gravity separation, and sulfide sulfur by chemical processes. If most of the sulfur is in the form of pyrite, then the amount that can be removed is dependent on the size of the crystals. If the crystals are relatively large then they can easily be removed by gravity separation, but if the crystals are small, it may be harder to remove them. Small crystals may be concentrated in the larger size coals or the smaller size coals. It is therefore impossible to draw any conclusions regarding the sulfur content of various size coals.

TABLE 1. SUMMARY OF PHYSICAL COAL CLEANING UNIT OPERATIONS[8]

Unit operation	Description	Efficiency	Remarks
Jigging	A pulsating fluid stratifies coal particles in increasing density from top to bottom. The cleaned coal is overflowed at the top.	N.A.	Most popular and least expensive coal washer available, but may not effect as accurate a separation as desired. Sizes: 3.4 to 76 mm (6 mesh to 3 in.).
Washing Tables	Pulverized coal and water are floated over a table shaken with a reciprocating motion. The lighter coal particles are separated to the bottom of the table, while the heavier, larger, impure particles move to the sides.	N.A.	Sizes: 0.15 to 6.4 mm (100 mesh to 1/4 in.).
Dense or Heavy Media	Coal is slurried in a medium with a specific gravity close to that at which the separation is to be made. The lighter, purer coal floats to be top and is continuously skimmed off.	N.A.	Advantages: Ability to make sharp separations at any specific gravity within the range normally required; ability to handle wide range of sizes; relatively low capital and operating costs when considered in terms of high capacity and small space requirements; ability to handle fluctuations in feed quantity and quality. Sizes: 0.59 to 200 mm (28 mesh to 8 in.).
Hydrocyclones	The separating mechanism is described as taking place in the ascending vortex. The high and low specific gravity particles moving upward in this current are subjected to centrifugal forces effecting separation.	N.A.	If maximum pyrite reduction and maximum clean coal yield are to be obtained, supplemental processes such as cyclone classifying, fine mesh screening and froth flotation are necessary (on stream process). Hydrocyclones presently are used in the U.S. to clean flotation--sized coal, but can be used for coal as coarse as 64 x 0 mm. (1/4 x 0 in.).
Humphrey Spiral	Coal-water slurry is fed into a spiral conduit. As it flows downward, stratification of the solids occurs with the heavier particles concentrated in a band along the spiral. An adjustable splitter separates the stream into two products--a clean coal and the middlings.	N.A.	Has shown significant ash and sulfur reduction on 0.42 x 0 mm (35 x 0 mesh) Middle Kittanning coal.

(continued)

TABLE 1 (continued)

Unit operation	Description	Efficiency	Remarks
Launder-type Washer	Raw coal is fed into the high end of a trough with a stream of water. As the stream of coal and water flows down the incline, particles having the highest settling rate settle into the lower strata of the stream. These are the middling or refuse particles. The clean coal particles gravitate into the upper strata before separation.	N.A.	Three types of launders are recognized based upon mode of transport. Sizes: 4.76 to 76 mm (4 mesh to 3 in.).
Pneumatic	Coal and refuse particles are stratified by means of pulsating air. The layer of refuse formed travels forward into pockets or wells from which it is withdrawn. The upper layer of coal travels over the refuse and is removed at the opposite end.	N.A.	Most acceptable preparation methods from the standpoint of delivered heating value cost. Sizes: Up to 6.4 mm (1/4 in.).
Froth Flotation	A coal slurry is mixed with a collector to make certain fractions of the mixture hydrophilic. A frother is added and finely disseminated air bubbles are passed through the mix. Air-adnering particles are floated to the top of the remaining slurry and are then removed as a concentrate.	N.A.	Froth flotation is used to reproduce pyrite in English coals; the flotation of coal refuse to obtain salable pyrite is uneconomical in view of todays poor sulfur market; if ethylxanthate is used as the collector, it is absorbed onto coal pyrite in such a manner as to make it ineffective for flotation. Sizes: 1.17 to 0.044 mm (14 to 325 mesh).
Two stage Flotation for Pyrite	Experimental coal flotation process in which the coal is floated while high ash impurities are rejected. The froth concentrate is then repulped in H_2O, treated with an organic colloid to depress coal. A xanthate collector and alcohol frother are added and then refloated.	Pyritic sulfur reduced 90% with 80% recovery	Frothing agent--methylisobutyl carbinol; pH regulators--NaOH and HCl; Coal Depressant-Aero Depressant 633; Pyrite flotation collector--potassium amylxanthate. In general the ratio of readily flotable coal increases with an increase in fixed carbon content. Therefore, increased rank yields an increased ratio.

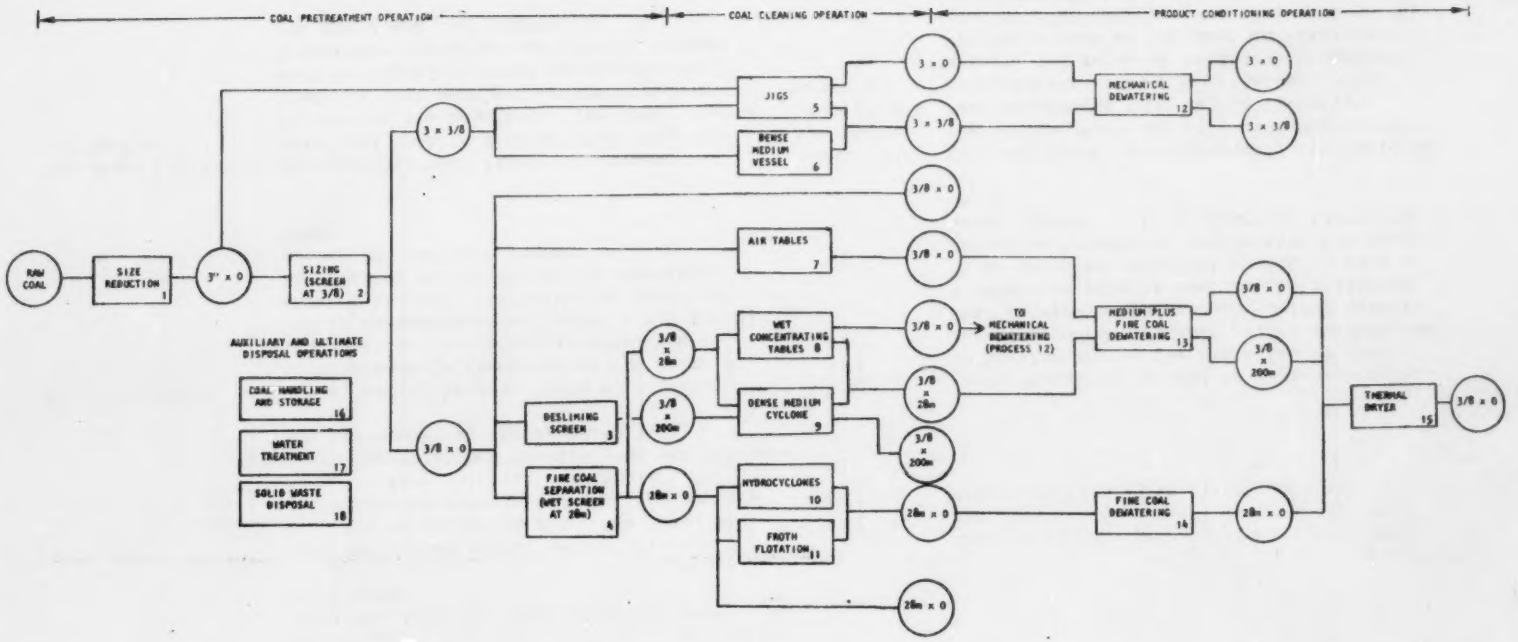

Figure 1. Process for physical coal cleaning systems.[9]

SECTION 3

SOURCE DESCRIPTION

GCA identified, by the previously described methods, 165 physical coal cleaning plants with capacities greater than 500 ton/hr of raw coal feed. These plants are listed in Table 2 along with the capacity in ton/day, ton/hr or both, as well as the types of equipment utilized at each plant contingent upon availability of the data. These plants represent a spectrum of physical coal cleaning technology ranging in complexity from plants that merely use jigs to process coarse coals to plants that clean all sizes of coals.

Illinois has 27 plants, Ohio has 12 and Indiana has 7. Other states in EPA Region V do not have any coal cleaning plants larger than 500 ton/hr. West Virginia, with 44 plants, has more coal cleaning plants than any other state. Other states with many plants are Kentucky with 25 plants, Pennsylvania with 17 plants, Virginia with 13 plants and Alabama with 7 plants.

According to the results in Table 2 wet cyclones are the most common type of coal cleaning equipment with 103 plants using these devices. Heavy media washers are used at 91 plants and flotation units are used at 80 plants. Jigs and washing tables are reportedly used by 63 and 48 plants, respectively. Centrifuges are used at 109 plants for dewatering. About 70 plants report the use of thermal dryers. The number of plants using the different types of equipment does not reflect the amount of coal cleaning by each method because capacities and utilization of each type of equipment can vary.

Table 3 presents the latest data on the total amount of coal that is mechanically cleaned and the methods that are used.[40-42] Unfortunately, 1978 is the last year that the Federal government collected this type of data.[42] The data in Table 3 show that jigs and dense media processes are used to clean the largest amounts of coal. Flotation processes are used to clean only a small fraction of the total coal produced.

Trends in the use of coal cleaning in the 1970 to 1978 period do not show the results that might have been anticipated. The total amount of coal cleaned declined between 1970 and 1974 and between 1974 and 1978. The use of flotation processes and dense media separators remained relatively constant. The amount of coal cleaned by jigs and washing tables declined from 1970 to 1978. Startup of new plants since 1978 may have changed the picture presented in Table 3 but data are not available.

TABLE 2. COAL PREPARATION PLANTS WITH CAPACITIES GREATER THAN 500 TONS/HR[1]

State[1]	Company[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/hr)	H[a]	F[b]	CY[c]	C[d]	FF[e]	M[f]	J[g]	DF[h]	W[i]
AL	Alabama By-Products Corp.	Mary Lee No. 1	Goodsprings	-	1,200[10]	0	x[j]	x	0	x	0	-[k]	0	0
AL	U.S. Steel	Concord Mine	Hueytown	12,500	-	0	4	11	0	0	0	0	9	03
AL	Jim Walker Resources, Inc.	Bessie Mine	Birmingham	-	800[11]	1	2	0	1	1	2	0	11	12
		Blue Creek No. 3	Adger	10,000	800[11]	2	2	0	4	2	5	0	0	30
AL	Jim Walker Resources, Inc.	Blue Creek No. 4	Brockwood	10,000	800[11]	3	3	0	4	2	5	0	0	32
AL	Jim Walter Resources, Inc.	Blue Creek No. 5	Brockwood	10,000	800[11]	0	4	8	6	2	8	0	0	
AL	Jim Walter Resources, Inc.	Blue Creek No. 7	Brockwood	10,000	800[11]	0	4	8	6	2	8	0	0	0
AR	Titan Mining Co.	Scranton Mine	Little Rock	5,000	-									
CO	Snow Mass Coal Co.	Thompson Creek Mine Nos. 1 & 3	Carbondale	4,000	-	1	0	3	2	0	0	0	2	2
IL	Amax Coal Co.	Leahy Mine	Campbell Hill	12,000	1,100[2]	0	0	8	6	0	0	2	0	0
IL	Consolidation Coal Co., Midwestern Region	Burning Star No. 2 Mine	DuQuoin	6,500	1,200[12]	0	0	0	0	0	0	2	x	0
IL	Consolidation Coal Co., Midwestern Region	Burning Star No. 3 Mine	Sparta	6,500	600[12]									
IL	Consolidation Coal Co., Midwestern Region	Burning Star No. 4 Mine	Cutler	-	1,000[12]									
IL	Consolidation Coal Co., Midwestern Region	Burning Star No. 5 Mine	Desoto	-	700[12]									

(continued)

TABLE 2 (continued)

State[1]	Company[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/hr)	H[a]	F[b]	CY[c]	C[d]	FF[e]	M[f]	J[g]	DF[h]	A[i]
IL	Freeman United Coal Mining Co., Div. Material Service Corp.	Buckheart Mine No. 17	Canton	7,000	900[13]	-	0	0	x	0	0	0	0	0
IL	Freeman United Coal Mining Co., Div. Material Service Corp.	Orient Mine No. 3	Waltonville	14,000	1,300[13]	x	x	0	0	0	x	x	x	0
IL	Freeman United Coal Mining Co., Div. Material Service Corp.	Orient Mine No. 6	Waltonville	6,000	1,200[13]	x	x	0	0	0	0	0	x	0
IL	Freeman United Coal Mining Co., Div. Material Service Corp.	Crown II Mine	Virden	-	1,300[13]	0	0	0	x	0	x	x	0	0
IL	Freeman United Coal Mining Co., Div. Material Service Corp.	Crown III Mine	Farmersville	-	1,300[13]									
IL	Freeman United Coal Mining Co., Div. Material Service Corp.	Fidelity Mine 11	DuQuoin	7,500	1,300[13]	0	0	x	0	x	0	x	0	0
IL	Freeman United Coal Mining Co., Div. Material Service Corp.	Orient Mine 4	Marion	7,000	500[13]	x	0	0	x	0	0	x	x	0
IL	Inland Steel Coal Co.	Inland Mine No. 1	Sesser	-	-	x	x	x	0	x	0	0	x	0
IL	Inland Steel Coal Co.	Inland Mine No. 2	Sesser	-	-	x	x	x	0	x	0	0	x	0
IL	Midland Coal Co., A Div. of ASARCO, Inc.	Elm Mine	Trivoli	7,000	-	0	0	6	3	0	0	1	3	0

(continued)

TABLE 2 (continued)

State[1]	Company[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/hr)	H[a]	F[b]	CY[c]	C[d]	FF[e]	M[f]	J[g]	JF[h]	W[i]
IL	Monterey Coal Co., A Div. of Exxon Coal USA, Inc.	Monterey No. 1 Mine	Carlinville	12,000	-	0	0	x	x	0	x	x	0	0
IL	Monterey Coal Co., A Div. of Exxon Coal USA, Inc.	Monterey No. 2 Mine	Albers	20,000	-	0	0	x	x	0	x	x	0	0
IL	Old Ben Coal Co.	Old Ben No. 25	Benton	-	-	0	x	x	x	0	0	x	x	0
IL	Old Ben Coal Co.	Old Ben No. 21	Sesser	-	-	x	x	0	x	0	0	x	x	0
IL	Peabody Coal Co.	Mine No. 10	Pawnee	15,500	-	0	0	0	0	0	0	x	0	0
IL	Peabody Coal Co.	Eagle No. 2 Mine	Shawneetown	10,000	-	0	0	0	x	0	0	x	0	0
IL	Peabody Coal Co.	River King U.G. No. 1 Mine	Freeburg	7,000	-	0	0	x	0	0	0	x	0	0
IL	Peabody Coal Co.	Will Scarlet Mine	Stonefort	6,500	-	0	0	0	0	0	0	x	x	0
IL	Sahara Coal Co., Inc.	Central Preparation Plant	Harrisburg	12,000	-	x	0	x	x	x	x	0	x	0
IL	Southwestern Illinois Coal Corp.	Captain Mine	Percy	-	-									
IL	Southwestern Illinois Coal Corp.	Streamline Mine	Percy	-	-	x	0	x	0	0	0	0	x	0
IL	Zeigler Coal Co.	Mine No. 11	Coulterville	4,000	-	0	x	0	0	0	x	x	0	0
IN	Amax Coal Co.	Minehaha Mine	Sullivan	8,000	850[14]	0	0	x	x	0	0	x	0	0
IN	Amax Coal Co.	Chinook	Brazil	5,500	1,200[14]									
IN	Amax Coal Co.	Ayrshire Mine	Chandler	16,000	1,600[14]	0	x	x	x	0	0	x	x	0
IN	Peabody Coal Co.	Universal Mine	Universal	6,000	-	0	0	x	0	0	0	x	0	0
IN	Peabody Coal Co.	Hawthorn Mine	Carlisle	5,000	-									
IN	Peabody Coal Co.	Lynville Mine Nos. 1 and 2	Lynville	14,000	-	0	0	x	x	0	0	x	x	x

(continued)

TABLE 2 (continued)

State[1]	Company[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/hr)	[a]	[b]	[c]	[d]	[e]	[f]	[g]	[h]	[i]
IN	Peabody Coal Co.	Squaw Creek Mine	Boonville	6,000	-	0	0	x	0	0	0	x	x	0
KY	Ambassador Coal Co.	Embassy Mine and Plant	Sturgis	4,000	-	0	0	14	3	1	0	x	0	0
KY	Bailey Mining Co.	Bailey Preparation Plant	Bypro	4,000	-	0	0	0	0	0	0	x	0	0
KY	Blue Diamond Coal Co.	Scotia, Upper Taggart Mines	Cumberland	5,000	-	x	x	x	x	x	x	0	0	0
KY	Blue Diamond Mining	Leatherwood Mine No. 1	Leatherwood	6,000	-									
KY	Chapperal Coal Corp.	Chapperal No. 2 Mine	Pikeville	8,000	-	0	0	0	x	.0	x	0	0	0
KY	Cimmaron Coal Corp.	Volunteer Mine	Madisonville	6,500	-	0	0	16	2	0	0	2	0	0
KY	Eastover Mining Co.	Darby No. 4 Mine	Highsplint	9,600	-	0	0	54	0	1	1	1	5	0
KY	Falcon Coal Co., Inc.	Breathitt County Operations	Jackson	25,000	-	0	0	8	1	0	0	1	1	0
KY	Kentucky Carbon Corp.	Kencar No. 1 and Preparation Plant	Phelps	10,000	-	4	0	20	12	2	4	0	0	28
KY	Leslie Coal Mining Co.	Leslie Mine	Sidney	8,700	-	x	x	x	x	x	x	0	0	0
KY	Mapco Inc.	Martiki Mine	Lovely	10,000	-	2	2	12	8	3	2	0	1	8
KY	Mapco Inc.	Pontiki Mine	Lovely	8,000	-	1	12	8	5	2	2	0	1	20
KY	Martin County Coal Corp.	Martin County Mines	Inez	17,500	-	2	2	15	6	1	1	0	1	20
KY	Middle States Coal Co.	Johnson Mine Nos. 5 and 5-A	David	4,000	-	2	0	3	3	1	0	0	0	0
KY	National Mines Corp.	Beaver Creek Div.	Wayland	10,000	-	2	2	16	6	2	1	0	1	6
KY	Peabody Coal Co.	River Queen Mine	Greenville	9,000	-	0	0	x	0	0	0	x	0	0

(continued)

TABLE 2 (continued)

State[1]	Company[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/hr)	H[a]	P[b]	CY[c]	C[d]	FT[e]	M[f]	JG	DY[h]	W[i]
KY	Peabody Coal Co.	Ken Mine	Beaver Dam	10,000	-	0	0	x	0	0	0	x	x	0
KY	Peabody Coal Co.	Camp No. 11 Mine	Morganfield	10,000	-	0	0	x	0	0	0	x	0	0
KY	The Pittsburgh & Midway Coal Mining Co.	Pleasant Hill Mine	White Plains	-	-	0	0	7	0	0	0	2	4	1
KY	The Pittsburg & Midway Coal Mining Co.	Colonial Mine	Madisonville	10,000	-	0	0	30	0	0	0	3	6	1
KY	River Processing, Inc.	Dunraven Prep. Plant No. 1	Hazard	8,400	-	1	0	x	x	x	x	0	x	x
KY	Russell Fork Coal Co., Inc.	Preparation Plant	Elkhorn City	4,500	-	0	0	0	0	0	0	0	0	x
KY	Shamrock Coal Co.	Shamrock Mine No. 18	Manchester	7,000	-	x	0	0	0	0	0	0	0	x
KY	South East Coal Co.	Preparation Plant	Irvine	15,000	-	x	4	x	7	x	x	2	x	0
KY	U.S. Steel Corp.	Corbin Cleaning Plant	Corbin	-	-	2	0	0	17	0	0	0	0	54
MD	Mapco Inc.	Mettiki Mine	Deer Park	8,000	-	0	6	96	13	6	15	0	1	0
MD	Associated Electric Cooperative, Inc.	Prairie Hill Mine	Huntsville	15,500	-	x	0	0	0	2	0	0	0	0
NM	Kaiser Steel	York Canyon Mine	Raton	6,000	-	x	0	4	3	1	0	0	0	0
NM	San Juan Coal Co.	San Juan Mine	Fruitland	17,500	-									
OH	Central Ohio Coal Co.	Muskingum Mine	Cumberland	12,000	600[15]	0	12	22	1	4	x	2	0	0
OH	Consolidation Coal Co., Midwestern Region	Georgetown Prep. Plant No. 19	Cadiz	15,000	-	0	2	16	13	2	2	2	0	32

(continued)

TABLE 2 (continued)

State[1]	Company[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/hr)	A[a]	B[b]	C[c]	D[d]	E[e]	F[f]	G[g]	H[h]	I[i]
OH	The Nacco Mining Co.	Powhatan No. 6	Alledonia	11,000	-	0	0	x	x	x	0	2	x	0
OH	Peabody Coal Co.	Broken Aro Mine	Coshocton	8,000	-	0	0	0	0	0	0	x	0	0
OH	Peabody Coal Co.	Sunny Hill Mine	New Lexington	9,000	-	0	0	0	0	0	0	x	x	0
OH	Quarto Mining Co.	Powhatan No. 4 Mine	Powhatan Pt.	7,500	-	0	0	x	x	x	0	2	0	0
OH	Quarto Mining Co.	Powhatan No. 7 Mine	Powhatan Pt.	8,400	-	0	0	x	x	x	0	x	x	0
OH	R&F Coal	Preparation Plant	Cadiz	15,000	-	x	0	x	x	x	0	0	0	0
OH	Southern Ohio Coal Co.	Meigs Mine No. 1	Athens	18,850	-	x	0	0	3	1	4	0	0	0
OH	Southern Ohio Coal Co.	Raccoon Mine No. 3	Athens	7,000	-	0	0	8	2	2	1	1	0	0
OH	Youghiogheny & Ohio Coal Co.	Allison Mine	Beallsville	5,000	-	0	0	0	4	1	1	2	0	0
OH	Youghiogheny & Ohio Coal Co.	Nelms Mine Cadiz Portal	Cadiz	5,000	-	0	0	0	1	0	1	1	0	0
PA	Avery Coal Co., Inc.	Van Tipple	Phillipsburg	7,000	-	0	0	0	3	0	0	x	2	0
PA	Bethlehem Mines Corp.	Cambria Slope No. 33 Mine	Ebensburg	-	-	0	x	x	x	x	0	0	x	0
PA	Canterbury Coal Co.	Canterbury Prep. Plant	Avonmore	-	600[1]	0	16	36	8	1	2	1	0	0
PA	Delta Coal Sales, Inc.	Delta No. 1 Tipple & Cleaning Plant	Grantsville, MD	4,320	-	0	1	7	0	2	1	1	4	0
PA	Duquesne Light Co.	Warwick Mine No. 3	Greensboro	18,000	-	x	0	x	x	x	x	0	0	0
PA	Greenwich Collieries Div.	North & South Mines	Ebensburg	13,000	-	0	0	24	8	4	2	2	2	0
PA	Iselin Preparation Co.	Homer City Coal Cleaning Plant	Homer City	20,000	-	x	0	158	16	4	0	0	4	16

(continued)

TABLE 2 (continued)

State[1]	Company[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/hr)	H[a]	F[b]	CY[c]	C[d]	FI[e]	M[f]	J[g]	DY[h]	W[i]
PA	Jones & Laughlin Steel Corp.	Vesta Preparation Plant	La Belle	16,000	-	14	8	12	16	7	1	0	0	12
PA	Jones & Laughlin Steel Corp.	Nemacolin Mine & Preparation Plant	Nemacolin	5,800	-	x	x	0	0	0	x	0	x	0
PA	Marmon Coal Co.	Plant No. 2	Boswell	7,000	-	x	x	x	x	x	x	0	0	0
PA	Republic Steel	Clyde Mine & Plant	Fredericktown	6,000	-	2	24	x	x	x	0	0	x	x
PA	Republic Steel	Banning No. 4[d] Plant	West Newton	4,000	-	2	24	0	x	0	0	0	x	x
PA	Shannon Coal Co.	Shannon Tipple	Clarion	7,000	-	0	0	0	0	0	0	x	0	0
PA	W.P. Stahlman Coal Co.	Stahlman Washery	Clarion	7,000	-	0	0	0	0	0	0	x	x	0
PA	U.S. Steel Corp.	Robena Mine	Greensboro	20,000	-	x	0	0	x	x	x	0	x	0
PA	U.S. Steel Corp.	Maple Creek Mines Nos. 1 & 2	New Eagle	15,000	-	x	x	x	x	x	x	0	0	0
PA	Universal Minerals, Inc.	Mine No. 1116-2,3,4	Portage	7,000	-	1	0	3	1	0	1	0	0	13
TN	Consolidation Coal Co., Southern Applacia Region	Matthews Mine	Middlesboro, KY	6,000	550[16]	x	0	x	x	0	0	0	0	0
UT	Eureka Energy Co.	Sage Pt. - Dugout Canyon Project	San Francisco, CA	-	-	2	0	20	8	4	3	0	0	0
UT	SM Corp.	John Henry Mine	Hurricane	-	-	0	0	3	0	0	0	3	0	0
UT	Kaiser Steel Corp.	Central Preparation Plant	Sunnyside	9,000	-	0	20	0	2	2	0	2	0	0
UT	Plateau Mining Co.	Star Pt. Mine Nos. 1 & 2	Price	5,600	300-500	0	0	3	2	1	0	0	0	0

(continued)

TABLE 2 (continued)

State[1]	Company[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/hr)	A[a]	B[b]	C[c]	D[d]	E[e]	F[f]	G	H[h]	I[i]
WV	Price River Coal Co.	Price Mine No. 3	Helper	-	1,250[15]	2	4	28	6	x	x	0	0	0
WV	U.S. Steel Corp.	Wellington Prep. Plant	E. Wellington	7,500	-	x	x	x	x	x	0	0	x	0
VA	Clinchfield Coal Div. of the Pittston Co.	Moss Preparation Plant 1	Coeburn	9,000	750[15]	x	0	0	0	0	0	0	5	0
VA	Clinchfield Coal Div. of the Pittston Co.	Moss Mine No. 2	Dante	5,000	625[15]	x	0	0	0	0	1	0	11	x
VA	Clinchfield Coal Div. of the Pittston Co.	Moss Preparation Plant 3	Dante	17,500	1,600[15]	x	x	0	0	0	0	0	27	x
VA	Clinchfield Coal Div. of the Pittston Co.	McClure River Prep. Plant	Dante	-	550[15]	x	x	x	x	x	x	0	x	0
VA	Island Creek Coal Co.	Virginia Pocahontas No. 6 Mine	Keen Mountain	8,000	-	x	x	x	x	x	x	0	x	x
VA	Jewell Coal & Coke Co.	Coronet No. 2	Vansant	7,500	-	x	x	0	0	0	0	0	x	0
VA	Paramont Mining Corp.	Ramsey Plant	Wise	13,500	-	x	x	x	x	x	0	0	x	0
VA	Permac Inc.	Permac Mine No. 3	Oakwood	6,000	-	2	1	x	x	x	x	0	0	x
VA	United Coal Co.	Virginia Coal Div. (Wellmore Coal Corp.)	Grundy	-	-	x	x	x	x	x	x	0	x	x
VA	United Coal Co.	Wellmore No. 7 Plant Mine No. 1225	Big Rock	-	-	x	x	x	x	x	x	0	x	0
VA	Virginia Iron, Coal & Coke Co.	Dale Ridge Washer	Coeburn	7,500	-	0	0	0	x	0	0	x	x	x

(continued)

TABLE 2 (continued)

State[1]	Company[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/hr)	H[a]	F[b]	CY[c]	C[d]	FI[e]	M[f]	JS	DT[h]	W[i]
VA	Westmoreland Coal Co.	Bullitt Mine	Big Stone Gap	8,500	1,000[19]	2	4	8	19	0	1	0	0	32
WA	Washington Irrigation and Development Co.	Centralia Mine	Centralia	20,000	-	0	0	6	3	0	0	2	0	0
WV	Affinity Mining Co.	Keystone No. 5 Mine	Sophia	5,000	-	x	x	x	0	0	0	0	x	0
WV	Amherst Coal Co.	McGregor Cleaning Plant	Yolyn	4,200	800[20]	x	6	16	3	2	4	0	2	0
WV	Armco Inc., Material Resources Div.	Robin Hood Div. Preparation Plant	Twilight	6,000	-	x	x	0	x	x	x	0	x	0
WV	Armco Inc., Material Resources Div.	Walhonde Div. Mine No. 10 A & B	Sundial	6,000	-	x	x	x	x	x	x	0	x	0
WV	Armco Inc., Material Resources Div.	Walhonde Div. Sundial Preparation Plant	Sundial	6,000	-	x	x	x	x	x	x	0	x	0
WV	Armco Inc., Material Resources Div.	Harewood Mine	Longacre	12,000	-	x	x	4	6	2	1	0	0	x
WV	Badger Coal Co.	Grand Badger Mine	Philippi	-	500[21]	x	x	x	x	x	x	0	x	0
WV	Beckley Coal Mining Co.	Beckley Mine	Glenn Daniel	-	700[22]	x	x	x	x	x	0	0	x	x
WV	Big Mountain Coals	Prenter Preparation Plant	Prenter	4,000	-	2	1	x	x	1	0	0	0	0
WV	Bishop Coal Co.	Bishop Mines	Bishop	-	500[23]	x	x	x	x	x	0	0	0	0
WV	Bronco Mining Co., Inc.	Bronco Preparation Plant	Kingwood	9,100	-	0	x	x	x	x	0	0	x	x

(continued)

TABLE 2 (continued)

State[1]	Company[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/hr)	H[a]	F[b]	CY[c]	C[d]	FI[e]	I[f]	S[g]	DI[h]	A[i]
WV	Buffalo Mining Co.	Lorado Preparation Plant	Lorado	4,500	-	0	3	3	0	0	0	x	0	0
WV	Cannelton Industries, Inc.	Kanawha Div. Mines, Lady Dunn	Cannelton	5,000	500[24]	x	x	0	x	x	x	0	0	x
WV	Carbon Fuel Co.	Morton Mine Eagle Plant	Winifrede	5,500	750[25]	2	9	10	5	2	2	0	4	24
WV	Carbon Fuel Co.	Carbon Blue	Carbon	5,500	650[25]	1	0	28	8	1	1	0	0	12
WV	Carbon Fuel Co.	Kentucky Carbon	Phelps, KY	-	800[25]									
WV	Cedar Coal Co.	Big John No. 4 Mine	Cabin Creek	12,000	-	2	8	10	13	1	4	0	0	0
WV	Consolidation Coal Co., Northern West Virginia Region	Blacksville No. 2 Mine	Wana	19,200	-	1	0	0	4	0	2	0	0	0
WV	Consolidation Coal Co., Northern West Virginia Region	Mine No. 95, Robinson Run	Sninnston	12,000	-	2	4	0	8	2	1	0	1	26
WV	Consolidation Coal Co., Northern West Virginia Region	Loveridge Mine No. 22	Fairview	13,000	-	0	0	0	11	0	2	2	2	4
WV	Consolidation Coal Co., Northern West Virginia Region	Arkwright Preparation Plant	Osage	17,200	-	1	0	0	0	0	3	0	0	0
WV	Consolidation Coal Co., Northern West Virginia Region	Humphrey Preparation Plant	Osage	15,700	-	1	0	0	0	2	1	0	12	48
WV	Consolidation Coal Co., Eastern Region	Ireland Mine	Moundsville	-	1,500[26]	2	4	2	0	1	1	0	0	0
WV	Consolidation Coal Co., Eastern Region	McElroy Mine	Moundsville	-	1,500[26]	2	5	6	3	1	1	0	0	0
WV	Consolidation Coal Co., Eastern Region	Shoemaker Mine	Moundsville	-	1,000[26]	2	5	6	3	1	1	0	0	0

(continued)

TABLE 2 (continued)

State[1]	Company[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/hr)	A[a]	F[b]	CY[c]	C[d]	FT[e]	M[f]	JG	DY[n]	WI
WV	Eastern Association Coal Corp.	Harris Mine Nos. 1 & 2	Bald Knob	10,000	-	x	0	0	0	0	0	0	x	0
WV	Eastern Association Coal Corp.	Federal Mine 1	Grant Town	12,500	-	x	x	0	0	0	x	x	x	x
WV	Eastern Association Coal Corp.	Joanne Mine	Racnel	6,500	-	0	x	0	0	x	1	x	2	x
WV	Eastern Association Coal Corp.	Federal Mine 2	Fairview	12,500	-	x	0	0	x	0	x	0	x	0
WV	Eastern Association Coal Corp.	Kopperston Mine 1	Kopperston	12,000	-	x	x	0	x	0	x	x	x	x
WV	Elkay Mining Co.	Rum Creek Preparation Plant	Lyburn	-	825[27]	x	x	x	x	x	x	0	x	x
WV	Itmann Coal co.	Itmann Mines	Itmann	9,000	-	x	x	x	x	x	0	0	x	x
WV	Maple Meadow Mining (Sub. of Cannelton Ind.)	Mine No. 2	Summersville	7,000	600[24]	x	x	x	x	x	x	0	x	0
WV	Monterey Coal Co., A Div. of Exxon Coal USA, Inc.	Wayne Mine	East Lynn	-	-	x	x	x	x	0	x	0	0	0
WV	The New River Co.	Meadow Creek Preparation Plant	Mount Hope	8,400	-	2	3	38	4	3	1	0	1	0
WV	Olga Coal Co.	Olga Mine & Preparation Plant	Coalwood	-	650-700	3	9		6		1	0	x	32
WV	Robinson Phillips Coal Co.	Nos. 55 & 64 and Ace Mines	Pineville	4,000	400-500	x	x	x	x	x	0	x	0	0
WV	Royal Coal Co.	Royal Mines	Layland	5,000	500[20]	1	2	6	2	2	1	x	6	20
WV	Semet-Solvay Div. Allied Chemical Corp.	Shannon Branch Mine	Capels	11,000	500[31]	1	8	43	0	3	1	0	0	0

(continued)

TABLE 2 (continued)

State[1]	Company[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/hr)	H[a]	F[b]	CY[c]	C[d]	FT[e]	M[f]	J[g]	DY[h]	W[i]
WV	Southern Ohio Coal Co.	Martinka Mine No. 1	Fairmont	12,000	-	2	8	10	13	1	4	0	0	0
WV	U.S. Steel Corp.	Alpheus Cleaning Plant	Gary	-	-	x	x	x	0	0	x	x	x	x
WV	Valley Camp Coal Co.	Valley Camp No. 1	Triadelphia	-	500[32]	0	0	0	x	x	x	x	x	0
WV	Valley Camp Coal Co.	Donaldson Mine Co., Donaldson Preparation Plant	Shrewsbury	8,000	500[32]	0	0	8	5	2	2	2	0	0
WV	Westmoreland Coal Co.	Ferrel Mine	Clothier	8,000	600[33]	1	2	6	3	2	1	0	1	16

[a]Heavy media washers.

[b]Flotation units.

[c]Hydrocyclones.

[d]Centrifuges.

[e]Filters.

[f]Magnets.

[g]Jigs.

[h]Dryers.

[i]Washing tables.

[j]Indicates that equipment present but quantity is unknown.

[k]Number indicates the quantity of the equipment used.

TABLE 3. SUMMARY OF THE APPLICATION OF MECHANICAL COAL CLEANING METHODS, 1000 TONS/YR[40-42]

	1970	1974	1978
Mechanical coal cleaning:			
Wet methods:			
Jigs	140,457	129,302	104,811
Washing tables	44,058	28,869	23,549
Classifiers	3,593	2,698	6,153
Launders	5,199	3,577	1,358
Dense medium processes	76,590	82,283	74,512
Flotation	10,694	10,863	10,068
Pneumatic methods	17,855	7,557	4,330
Total	323,452	265,150	224,780
Crushed or screened	264,182	293,997	332,353
No processing	15,298	44,372	107,994
Total production	602,932	603,406	665,127
Thermal drying	64,165	36,045	23,282

More detailed information was collected on the sulfur and ash content of raw and prepared coals in order to determine the percent reduction by weight obtained through physical coal cleaning. Numerous plants were contacted and letters sent requesting information on the sulfur and ash contents of the raw and prepared coals. Unfortunately, GCA received responses from a limited number of plants. GCA was informed by many companies that the information is confidential or proprietary and cannot be released. However GCA was able to obtain additional information on 49 of the 165 physical coal cleaning plants with capacities greater than 500 ton/hr.

As previously cited, physical coal cleaning is capable of removing, on the average, about 50 percent of the pyrite sulfur and 30 percent of the total sulfur.[9] The State of Illinois in publication entitled Sulfur Reduction of Illinois Coals--Washability Studies, Part 1, stated that the amount of sulfur removed from 37 samples taken from 32 Illinois mines; representing 8 different seams varied from 10 percent to 50 percent and averaged about 25 percent.[34]

Table 4 presents the percent reduction in ash and sulfur by weight from 49 different coal preparation plants. Percent sulfur reduction varied from 0 to 57 percent and ash reduction varied from 10 to 85 percent. It should be noted that in some cases the percent sulfur in the prepared coal is greater than in the raw coal. This occurs because during cleaning much of the mineral matter which contains little sulfur is removed while, in some cases, little sulfur is removed from the coal itself, thus increasing the percentage of sulfur in the cleaned coal. It should be noted that the cleaned coal has a higher heating value than the raw coal, so the cleaned coal may have a lower sulfur content per Btu content. Unfortunately, heating values were not available in most cases, so percent sulfur reduction could not be calculated based on $lb/10^6$ Btu. Calculations were based on the following when Btu values were not available:

$$100 - \left(\frac{\% \text{ total sulfur in product}}{\% \text{ total sulfur in raw coal}} \times 100 \right)$$

When Btu values were reported the calculations were based on the following:

$$100 - \left(\frac{\% \text{ total sulfur in product}}{\text{Btu in product}} \div \frac{\% \text{ total sulfur in raw coal}}{\text{Btu in raw coal}} \right) \times 100$$

When the sulfur content in the product was equal to or greater than the sulfur content in the raw coal, calculations on percent sulfur reduction were not performed unless the Btu values were reported.

It is important to note how the percentage reductions of sulfur and ash were calculated. When the calculations are not based on Btu content then the values arrived at are conservative, as they assume the heating value of the raw coal is equal to the heating value of the cleaned coal. Actually the heating value of the cleaned coal is always higher than the raw coal. Calculations based on percent sulfur/Btu content take into consideration the

TABLE 4. PERCENT REDUCTION OF ASH AND SULFUR FROM SELECTED COAL PREPARATION PLANTS

State[1]	Company name[1]	Unit name[1]	Location[1]	Raw coal		Cleaned coal		Ash reduction %	Sulfur reduction %	Comments
				Ash %	Sulfur %	Ash %	Sulfur %			
AL	Alabama By-Products Corp.	Mary Lee No. 1	Goodsprings	Do not analyze[10]		15[10]	0.8[10]	-	-	
						13	1.4-1.6	-	-	American seam.[10]
AL	Jim Walter Resources, Inc.	Bessie Mine	Birmingham	45[11]	1.0	12.0	1.10	81	-	
		Blue Creek No. 3	Adger	41[11]	0.45[11]	8.0[11]	0.45[11]	81	0	Steam.
						12.0[11]	0.45[11]	71	0	Metal.
		Blue Creek No. 4	Brockwood	42	0.93	9.0	0.91	79	-	
		Blue Creek No. 5	Brockwood	45	0.71	9.0	0.82	80	-	
		Blue Creek No. 7	Brockwood	45	0.42	8.0	0.69	82	-	
IL	Amax Coal Co.	Leahy Mine	Campbell Hill	20[2]	4.5-4.75[2]	10-10.5[2]	3.0-3.5[2]	47-50	22-37	
IL	Consolidation Coal Co., Midwestern Region	Burning Star No. 2	DuQuoin	20-25[12]	4.0-4.5[12]	11-12[12]	3.4[12]	40-56	15-25	
		Burning Star No. 3	Sparta	20-25[12]	4.0-4.5[12]	11-12[12]	3.4[12]	40-56	15-25	Cleaned coal percentages based on yearly average values.
		Burning Star No. 4	Cutler	20-25[12]	4.0-4.5[12]	11-12[12]	3.4[12]	40-56	15-25	
		Burning Star No. 5	DeSoto	20-25[12]	4.0-4.5[12]	11-12[12]	3.4[12]	40-56	15-25	
IL	Freeman United Coal Mining Co., Div. Material Service Corp.	Buckheart Mine No. 17	Canton	21.0[13]	3.8[13]	11.6[13]	3.3[13]	45	13	
		Crown II	Virden	20.0[13]	5.0[13]	9.9[13]	4.1[13]	51	18	
		Crown III	Farmersville	32.0[13]	4.0[13]	10.8[13]	4.1[13]	66	-	
		Fidelity Mine II	DuQuoin	11.3[13]	4.1[13]	11.3[13]	3.5[13]	-	15	
		Orient Mine No. 3	Waltonville	22.0[13]	2.6[13]	8.5[13]	2.1[13]	61	19	
		Orient Mine No. 4	Marion	28.0[13]	2.3[13]	9.2[13]	1.6[13]	67	31	
		Orient Mine No. 6	Waltonville	23.5[13]	2.2[13]	7.7[13]	1.8[13]	67	18	

(continued)

TABLE 4 (continued)

State[1]	Company name[1]	Unit name[1]	Location[1]	Raw coal Ash %	Raw coal Sulfur %	Cleaned coal Ash %	Cleaned coal Sulfur %	Ash reduction %	Sulfur reduction %	Comments
IN	Amax Coal Co.	Ayrshire	Chandler	13.1	4.32	10.7	3.63	18	16	#6 seam.
		Chinook Mine	Brazil	16.16	5.67	10.82	4.56	33	20	#3 seam.
		Minnehaha Mine	Sullivan	16.35	4.02	10.83	1.73	34	57	#6 seam.
				12.1	1.25	10.83	1.73	10	-	#7 seam.
OH	Central Ohio Coal Co.	Muskingum Mine	Cumberland	20-32	5-10	11-14	4.3-4.7	30-66	6-57	
OH	Consolidation Coal Co., Midwestern Region	Georgetown Prep. Plant No. 19	Cadiz	27[35]	3.1[35]	8[35]	2.7[35]	70	13	Mine[35] #65A Seam[35] #8 — Coals from 9 mines are fed to Prep. Plant.
				34.5	2.25	9.25	2.6	73	-	#12 #8
				17.0	4.1	8.1	3.7	52	10	#13 #8
				12.4	3.3	8.0	2.3	35	31	#33 #9
				40	2.6	7.7	2.5	81	4	#7 #6A
				29	4.0	8.7	3.5	70	13	#125 #8
				30	2.2	7.8	2.35	74	-	#65B #8
				18	3.6	7.3	3.0	17	17	#24 #8
				16.5	3.2	8.6	2.4	25	25	#12 #9
UT	Plateau Mining Co.	Star Point Mine Nos. 1 & 2	Price	15.0[17]	0.6[17]	2.0-3.0[17]	0.6[17]	80-83	-	
UT	Price River Coal Co.	Price Mine No. 3	Helper	12.8[15]	0.5[15]	8.0[15]	0.48[15]	37	4	Percentage values based on yearly averages.
VA	Clinchfield Coal Div. of the Pittston Co.	McClure River Prep. Plant	Dante	30[18]	0.91[18]	8.0[18]	0.84[18]	81	33	Raw dry Btu = 10,290. Met dry Btu = 14,260.
		Moss Preparation Plant No. 1	Coeburn	27.9[18]	0.69[18]	5.6[18]	0.73[18]	85	23	Raw dry Btu = 10,550.
						15.0	0.74	56	12	Met dry Btu = 14,565. Midds dry Btu = 12,900.
		Moss Mine No. 2	Dante	25.2[18]	0.62[18]	7.8[18]	0.69[18]	76	14	Raw dry Btu = 10,975. Met dry Btu = 14,270.

(continued)

TABLE 4 (continued)

State[1]	Company name[1]	Unit name[1]	Location[1]	Raw coal		Cleaned coal		Ash reduction %	Sulfur reduction %	Comments
				Ash %	Sulfur %	Ash %	Sulfur %			
		Moss Prep Plant No. 3	Dante	35.4[18]	0.61[18]	6.0[18] 17.5	0.71[18] 0.69	89 63	25 15	Raw dry Btu = 9,390. Met dry Btu = 14,525. Steam dry Btu = 12,540.
VA	Westmoreland Coal Co.	Ballat Mine	Big Stone Gap	30.1[19]	0.79[19]	4.1[19]	0.63[19]	73	19	Percentage values based on an 8 month period. Raw dry Btu = 10,398. Steam dry Btu = 13,550.
WV	Amherst Coal Co.	McGregor Cleaning Plant	Yolyn	20-35[20]	1.6[20]	5.5-9[20]	1.0[20]	55-64	37	
WV	Badger Coal Co.	Grant Badger Mine	Philippi	35[21]	1.6[21]	14[21]	0.9[21]	60	44	
WV	Beckley Coal Mining Co.	Beckley Mine	Glenn Daniel	31[22]	0.98[22]	5.5[22]	0.83[22]	82	14	
WV	Cannelton Industries Inc.	Kanawha Div. Mines, Lady Dunn	Cannelton	25-30[24] 30-35	1.0[24] 1.0	6.0[24] 10-11	1.0[24] 0.7-0.8	76-80 63-71	- 30	Metal. Steam.
WV	Carbon Fuel Co.	Carbon Blue	Carbon	45[25]	1.25[25]	6.75[25]	0.9[25]	85	28	
		Kentucky Carbon	Phelps, KY	20[25]	0.45[25]	7.5[25]	0.55[25]	63	-	
		Morton Mine, Eagle Plant	Winifrede	35[25]	0.65[25]	6.5[25]	0.75[25]	81	-	
WV	Consolidation Coal Eastern Region	Ireland Mine	Moundsville	17.42[26]	4.84[26]	7.42[26]	4.2[26]	57	13	
		McElroy Mine	Moundsville	17.42[26]	4.8[26]	7.42[26]	4.5[26]	59	6	
		Shoemaker Mine	Moundsville	14.56[26]	4.2[26]	7.42[26]	3.85[26]	49	8	
WV	Elkay Mining Co.	Rum Creek Prep. Plant	Lyburn	27[27]	0.76[27]	7.0-7.5[27]	0.72-0.74[27]	72-74	3-5	

(continued)

TABLE 4 (continued)

State[1]	Company name[1]	Unit name[1]	Location[1]	Raw coal		Cleaned coal		Ash reduction %	Sulfur reduction %	Comments
				Ash %	Sulfur %	Ash %	Sulfur %			
WV	Maple Meadow Mining (Sub. of Cannelton Ind.)	Mine No. 2	Summersville	25-30[24] 30-35	1.9[24] 1.0	[illegible][24] 10-11	1.0[24] 0.7-0.8	79-83 63-71	- 30	Metal. Stean.
WV	Olga Coal Co.	Olga Mine and Prep. Plant	Coalwood	-	0.75[28]	5.5[28]	0.75[28]	-	-	
WV	Robinson Philips Coal Co.	Nos. 55 & 64 and Ace Mines	Pineville	12-25[29]	0.8-1.3[29]	6.0[29]	0.8[29]	50-74	0-39	
WV	Royal Coal Co.	Royal Mines	Layland	21[30]	1.01[30]	4.14[30]	0.77[30]	80	24	Percentages are based on as-received values (moisture not compensated for).
WV	Semet-Solvay Div. Allied Chemical Corp.	Shannon Branch Mine	Capels	20-25[31]	0.75[31]	4.5[31]	0.75[31]	77-82	-	
WV	Valley Camp Coal Co.	Donaldson Mine Co., Donaldson Prep. Plant	Shrewsbury	33.8[32]	0.73[32]	16.5-17.0[3]	0.85[32]	43-50	-	Raw dry Btu = 9,600. Cleaned dry Btu = 11,250.
		Valley Camp Coal No. 1	Triadelphia	35[32]	3.4[32]	10.5[32]	3.2[32]	70	6	Raw dry Btu = 9,902. Cleaned dry Btu = 13,359.
WV	Westmoreland Coal Co.	Ferrel Mine	Clothier	30.0[33]	0.82-0.85	5.25[33]	0.76[33]	83	7-11	Raw dry Btu = 10,500. Cleaned dry Btu = 13,400.

gain in Btu value due to removal of ash and other mineral matter during coal cleaning and are more representative of the effectiveness of coal cleaning.

The type of coal washed, size(s) of coal washed and shipped, as well as the principal applications of the coal, such as metellurgical or steam, are presented in Table 5.

TABLE 5. SUMMARY OF COAL CHARACTERISTICS

State[1]	Company name[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/yr)	Type of coal(s) washed[1]	Range of sizes washed[1]	Range of sizes shipped[1]	Principal applications(s)[1]
AL	Alabama By-Products Corp.	Mary Lee No. 1[1]	Goodsprings[1]	-	1,200[10]	M+H vol Bit[5]	3"x0		85% steam
AL	Jim Walter Resources, Inc.	Brookwood Mine	Birmingham	-	800[11]	M+H vol Bit[5]	1-1/2"x0	1-1/2"x0	Steam
		Blue Creek No. 3	Adger	10,000	800[11]	M+H vol Bit[5]	1-1/2"x0	1-1/2"x0	Metal
		Blue Creek No. 4	Brookwood	10,000	800[11]	M+H vol Bit[5]	1-1/2"x0	1-1/2"x0	Steam
		Blue Creek No. 5	Brookwood	10,000	800[11]	M+H vol Bit[5]	1-1/2"x0	1-1/2"x0	Steam
		Blue Creek No. 7	Brookwood	10,000	800[11]	M+H vol Bit	1-1/2"x0	1-1/2"x0	Steam
IL	Amax Coal Co.	Leany Mine	Campbell Hill	12,000	1,100[2]	M+H vol Bit[5]	-	1-1/4"x0	Steam
IL	Consolidation Coal Co., Midwestern Region	Burning Star No. 2	DuQuoin	6,500	1,200[12]	M+H vol Bit[5]	-	-	Steam
		Burning Star No. 3	Sparta	6,500	600[12]	M+H vol Bit[5]	-	-	Steam
		Burning Star No. 4	Cutler	-	1,000[12]	M+H vol Bit[5]	-	-	Steam
		Burning Star No. 5	DeSoto	-	700[12]	M+H vol Bit[5]	-	-	Steam
IL	Freeman United Coal Mining Co., Div.	Buckheart Mine No. 17	Canton	7,000	900[13]	H vol C Bit	6"x0	1-1/2"x0	Steam
		Crown II	Virden	-	1,300[13]	H vol B Bit	1-1/2"x0	1-1/2"x0	-
		Crown III	Farmersville	-	1,300[13]	H vol B Bit	1-1/2"x0	1-1/2"x0	-
		Fidelity Mine II	DuQuoin	7,500	1,300[13]	H vol B Bit	1-1/4"x0	1-1/4"x0	-
		Orient Mine No. 3	Waltonville	14,000	1,300[13]	H vol B Bit	6"x3" 3"x0 1-1/2"x0 1/2"x0	1-1/2"x0	Steam

(continued)

TABLE 5 (continued)

State[1]	Company name[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/yr)	Type of coal(s) washed[1]	Range of sizes washed[1]	Range of sizes shipped[1]	Principal applications[1]
		Orient Mine No. 4	Marion	5,000	500[13]	H vol B Bit	6"x0	-	-
		Orient Mine No. 6	Waltonville	5,000	1,200[13]	H vol B Bit	6"x0	-	Steam
IN	Amax Coal Co.	Ayrshire Mine	Chandler	10,000	1,600[14]	H vol C Bit[5]	-	1-1/2"x0 3/8"x0	Steam
		Chinook Mine	Brazil	-	1,200[14]	H vol C Bit[5]	-	3/4"x0	Steam
		Minnehaha Mine	Sullivan	8,000	850[14]	H vol C Bit[5]	-	1-1/2"x0	Steam
OH	Central Ohio Coal Co.	Muskingum Mine	Cumberland	12,000	600[15]	H vol Bit[5]	5"x0	1-1/4"x0	Steam
OH	Consolidation Coal Co., Midwestern Region	Georgetown Prep. Plant No. 19	Cadiz	15,000	-	H vol Bit[5]	-	1-1/4"x0 1"x0	Steam
UT	Plateau Mining Co.	Star Point Mine Nos. 1 & 2	Price	5,000	350-500[17]	M-H vol Bit[5]	3"x0	1-5/8"x0	Steam
UT	Price River Coal Co.	Price Mine No. 3	Helper	-	1,250[15]	M-H vol Bit[5]	4"x0	4"x0	Steam
VA	Clinchfield Coal Div. of the Pittston Co.	McClure River Prep. Plant	Dante	-	550[18]	L-H vol Bit[5]	All	1-1/4"x0	Metal
		Moss Preparation Plant 1	Coeburn	9,000	750[18]	L-H vol Bit[5]	All	1-1/4"x1/4" 1-1/4"x0	Metal
		Moss Mine No. 2	Dante	5,000	625[18]	L-H vol Bit[5]	All	1-1/4"x1/4" 1-1/4"x0	Metal
		Moss Prep. Plant No. 3	Dante	17,500	1,600[18]	L-H vol Bit[5]	All	1-1/4"x1/4" 1-1/4"x0	Metal

(continued)

TABLE 5 (continued)

State[1]	Company name[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/yr)	Type of coal(s) washed[1]	Range of sizes washed[1]	Range of sizes shipped[1]	Principal application(s)[1]
VA	Westmoreland Coal Co.	Ballit Mine	Big Stone Gap	8,500	1,300[19]	L-M vol Bit[5]	2"x0	2"x0	Steam
VA	Amherst Coal Co.	Dingess Leasing Plant	Volga	4,200	800[20]	M+H vol Bit[5]	9"x0	egg, stove nut, 2" x 3/4 Stkr., Carb,	Metal
WV	Badger Coal Co.	Grant Badger Mine	Philippi	-	500[21]	M+H vol Bit[5]	All	1-1/4"x0	Steam Metal
WV	Beckley Coal Mining Co.	Beckley Mine	Glenn Daniel	-	700[22]	M+H vol Bit[5]	3"x0	1-3/4"x0	Metal
WV	Cannelton Industries Inc.	Kanawha Division Mines, Lady Dunn	Cannelton	6,000	600[24]	M+H vol Bit[5]	5"x0	-	Metal Steam
WV	Carbon Fuel Co.	Carbon Blue	Carbon	5,500	650[25]	M+H vol Bit[5]	2"x1/4"x0	2"x0 1/4"x0 2x1/4" 1/4"x1-1/4"	-
		Kentucky Carbon	Phelps, KY		800[25]	M+H vol Bit[5]	-	-	-
		Morton Mine, Eagle Plant	Winifrede	5,500	750[25]	M+H vol Bit[5]	5"x0	2"x0 1"x0	Metal
WV	Consolidation Coal Eastern Region	Ireland Mine	Moundsville	-	1,500[26]	M+H vol Bit[5]	6"x1/2"	1-1/4"x0	-
		McElroy Mine	Moundsville	-	1,500[26]	M+H vol Bit[5]	6"x3/8"	1-1/4"x0	-
		Shoemaker Mine	Moundsville	-	1,200[26]	M+H vol Bit[5]	5"x1/2"	1-1/4"x0	-
WV	Elkay Mining Co.	Rum Creek Prep. Plant	Lyburn	-	825[27]	M+H vol Bit[5]	All	1-1/4"x0	Steam Metal

(continued)

TABLE 5 (continued)

State[1]	Company name[1]	Unit name[1]	Location[1]	Capacity (tons/day)[1]	Capacity (tons/yr)	Type of coal(s) washed[1]	Range of sizes washed[1]	Range of sizes shipped[1]	Principal applications(s)[1]
WV	Maple Meadow Mining (Sub. of Cannelton Ind.)	Mine No. 2	Summersville	7,000	600[24]	M+H vol Bit[5]	-	-	Metal Steam
WV	Olga Coal Co.	Olga Mine and Prep. Plant	Coalwood	-	650-700[26]	M+H vol Bit[5]	6"x0	2"x0	Metal
WV	Robinson Philips Coal Co.	Nos. 55 & 54 and Ace Mines	Pineville	4,000	400-500[29]	M+H vol Bit[5]	4"x3/8"	5"x4" 4"x2" 1"x3/8" 3/8"x0	Metal
WV	Royal Coal Co.	Royal Mines	Layland	5,000	500[30]	M+H vol Bit[5]	4"x0	1-1/4"x0	Metal
WV	Semet-Solvay Div., Allied Chemical Corp.	Shannon Branch Mine	Capels	11,000	500[31]	M+H vol Bit[5]	1-1/4"x1/4" 1/4"x28M 28Mx0	1-1/4"x1/4" 1/4"x28M 28Mx0	Metal
WV	Valley Camp Coal Co.	Donaldson Mine Co., Donaldson Prep. Plant	Shrewsbury	8,000	500[32]	M+H vol Bit[5]	-	-	Steam
		Valley Camp Coal No. 1	Triadelphia	-	500[32]	M+H vol Bit[5]	4"x0	2"x0	Steam
WV	Westmoreland Coal Co.	Ferrel Mine	Clothier	8,000	600[33]	M+H vol Bit[5]	-	-	Steam

SECTION 4

COSTS AND CONSTRUCTION SCHEDULES

Several reports on the costs of physical coal cleaning plants encompassing expenses due to raw coal storage and handling, preparation plant equipment, refuse equipment, labor and overhead, environmental factors, energy costs, etc. are available. Cost, Energy, and Environmental Sensitivity Analysis of Coal Cleaning Technology for Industrial Boiler Applications[3] analyzed costs for 13 coal cleaning plants with the following design parameters;

- Plant input in each case is 544 metric tons per hour (600 tons per hour);
- Annual capacity throughput is 1.81 million metric tons (2.0 million tons) based upon a 13.3 hr operating day and 250 operating days per year;
- In all cases, the plant is located at the mine mouth, and all resources such as coal, water, power, etc., are assumed readily available;
- Coal storage, loading conveyors and product loading equipment is assumed to be part of the mine and has not been duplicated;
- All process equipment used is commercially available and proven;
- Actual equipment performance partition factors have been used to adjust raw coal washability characteristics to performance guaranteed specifications; and
- Design of pollution control facilities is based upon federal new source performance regulations--EPA standards for air and water quality, MSHA/OSM regulations for refuse disposal, and MSHA/OSHA noise limitations.

Table 6 presents a summary of the results of the study. Notice that the costs are presented two ways; \$/ton product and $\$/10^6$ Btu product. The latter method of presenting costs is preferred. The time basis for the costs is mid-1978 dollars.

TABLE 6. SUMMARY OF COAL CLEANING COSTS[3]

Region	Coal seam county, state	Design No.	% total sulfur			% pyritic sulfur			lb $SO_2/10^6$ Btu			% ash			Level of cleaning	Cleaning costs		% weight recovery	% energy recovery	Tons refuse ton product	Energy consumption (Btu/lb product)
			ROM coal	Clean coal	% Reduction	ROM coal	Clean coal	% Reduction	ROM Coal	Clean coal	% Reduction	ROM coal	Clean coal	% Reduction		$/ton product	$/$10^6$ Btu product				
Northern Appalachia	Upper Freeport Butler, PA	1	3.45	1.57	54	2.51	0.95	62	5.99	2.30	62	23.9	9.7	59	3	3.26	0.120	74.5	88.7	0.343	1,755
	Lower Kittanning Cambria, PA	2	1.86	1.22	34	1.34	0.67	50	2.75	1.72	37	12.8	5.7	55	3	1.81	0.064	92.0	95.9	0.060	450
	Upper Freeport Butler, PA	3	3.45	2.21	36	2.51	1.34	47	5.99	3.41	43	23.9	14.4	40	2	2.05	0.079	83.6	94.2	0.197	809
	Bakerstown Tucker, WV	6	0.92	0.62	11	NA	NA	NA	1.71	1.35	22	28.7	19.9	31	4	2.64	0.109	80.5	90.3	0.243	1,302
Central Apalachia	Clintwood Dickensen, VA	4	0.87	0.83	5	NA	NA	NA	1.25	1.15	8	11.2	8.1	28	4	3.00	0.134	89.9	93.0	0.112	1,084
	Upper Cliff Dekaib, AL	5	0.85	0.75	12	0.41	0.34	17	1.23	1.06	14	10.9	9.5	10	2	1.48	0.052	96.3	96.0	0.038	312
	Splash Dam Dickensen, VA	7	1.56	1.24	21	NA	NA	NA	2.77	1.77	36	25.9	9.7	63	4	3.02	0.108	74.4	92.1	0.344	1,207
	Eagle Buchanan, VA	8	1.18	0.94	20	NA	NA	NA	1.73	1.30	25	10.4	4.7	55	4	2.75	0.095	84.0	89.3	0.191	1,745
	Bagy Buchanan, VA	12	2.95	2.31	22	NA	NA	NA	5.04	3.55	30	23.1	15.5	33	2	1.56	0.060	84.3	93.8	0.196	830
Midwest	Illinois No. 6 Williamson, IL	9	4.35	3.30	24	3.13	1.80	42	8.89	5.34	40	29.9	11.4	62	3	3.01	0.122	72.4	91.6	0.381	1,240
	Illinois No. 5 Saline, IL	10	2.88	1.99	31	2.01	1.06	47	4.75	2.97	37	16.4	7.5	54	3	2.34	0.087	84.0	92.9	0.190	1,032
	Illinois No. 5 Saline, IL	11	2.88	1.85	36	2.01	0.91	55	4.75	2.75	42	16.4	7.1	57	4	2.75	0.102	79.8	88.6	0.253	1,729
Central West	Beaver Randolph, MO	13	5.22	4.05	22	NA	NA	NA	13.04	7.99	39	27.2	8.0	71	4	3.59	0.177	65.8	83.1	0.520	2,000

The level of cleaning is defined as follows:

- Level 1--Crushing and Sizing[36]--This design uses rotary breakers, crushers and screens for top size control and for the removal of coarse refuse.

- Level 2--Coarse Size Coal Beneficiation--Coal is crushed and sized, followed by dry screening at 9.5 mm (3/8 in.) and wet beneficiation of the plus 9.5 mm material with a jig or dense medium vessel. The minus 9.5 mm material is mixed with the coarse product without washing.

- Level 3--Coarse and Medium Size Coal Beneficiation--Coal is crushed and separated into three size fractions by wet screening. The plus 9.5 mm material is beneficiated in a coarse coal circuit. The 9.5 mm by 28 mesh material is beneficiated by hydrocyclones, concentrating tables or dense medium cyclones, and the 28 mesh by 0-material is dewatered and shipped with the clean coal or discarded as refuse.

- Level 4--Coarse, Medium and Fine Size Coal Beneficiation--Coal is crushed and separated into three or more size fractions by wet screening. All size fractions are beneficiated in individual circuits. Thermal drying of the minus 6.4 mm fraction may be necessary to control the moisture content of the product.

- Level 5--"Deep Cleaning" Coal Beneficiation--Level 5 is basically a level 4 plant in which one size fraction is rigorously cleaned to meet a low sulfur-low ash product specification. Two or three coal products are produced to various market specifications. This level also utilizes a fine coal recovery circuit to increase total plant recovery.

The following methodology was followed in designing and costing the 13 coal cleaning plants:[3]

- Four major coal supply regions were considered. These regions are Northern Appalachia, Central Appalachia, Midwest and Central West.

- Coals which are representative of each supply region were selected. The criteria in this selection is that the amount of reserve for each type of coal should be significant with approximately the same amount of sulfur content throughout. The coals chosen also provide a wide range of sulfur contents for the analysis of physical coal cleaning as a control technology for different regulatory options. These coals are listed in Table 6.

- For each coal type, a representative level of physical coal cleaning was determined from the ratio of pyritic to organic sulfur contents of the coal. These ratios and the percent total sulfur reductions are shown in Table 6.

- Feed properties and detailed washability data were obtained for each type of coal.

- From the feed properties, washability data and the predetermined cleaning level, an initial process flow diagram was devised and the process was computer simulated for each type of coal. This computer program developed by Battelle Columbus Laboratories is capable of simulating certain classification and physical cleaning devices commonly used in coal preparation plants. The dewatering sections of the designs, however, were hand calculated.

- Equipment selection, design and costing were carried out upon the information provided by equipment manufacturers. Open literature was also used whenever necessary. In each selection, care was exercised on the availability, commercial acceptance and use of the equipment.

- Equipment costs were used to estimate capital costs. Annualized costs were then calculated and presented on a cost for beneficiation basis (dollars/ton of clean coal and dollars/10^6 Btu of clean coal) excluding costs for coal lost to refuse.

- Environmental factors were estimated for the solid wastes and water discharges; and

- Energy factors were calculated and expressed in terms of total energy consumption per ton of product.

Coal Preparation Plant Design No. 9 located in Williamson, IL is presented as an example cost analysis of one of the 13 coal preparation plants. A flow diagram of the processes utilized at the plant is included in Figure 2. The detailed cost estimates based on mid-1978 dollars are included in Tables 7 to 14.[3]

For more detailed information concerning the economic basis of the study, the reader is referred to the original report.[3]

Case studies of physical coal cleaning costs for eight plants are presented in Environmental Assessment of Coal Cleaning Processes: Technology Overview.[9] This analysis based on a study by the Hoffman-Muntner Corporation examined the costs of a variety of plants ranging in complexity from simple jig processes to relatively complex circuits involving heavy medium cyclones, froth flotation cells, and thermal dryers ranging in capacity from 600 to 1400 tons/hr raw coal feed. Costs for these eight plants ranged from 0.176 to 0.338 \$/10^6 Btu recovered, based on mid 1977 dollars. These costs are somewhat higher than those reported in the previously referenced study. The reader is referred to this report for further details.

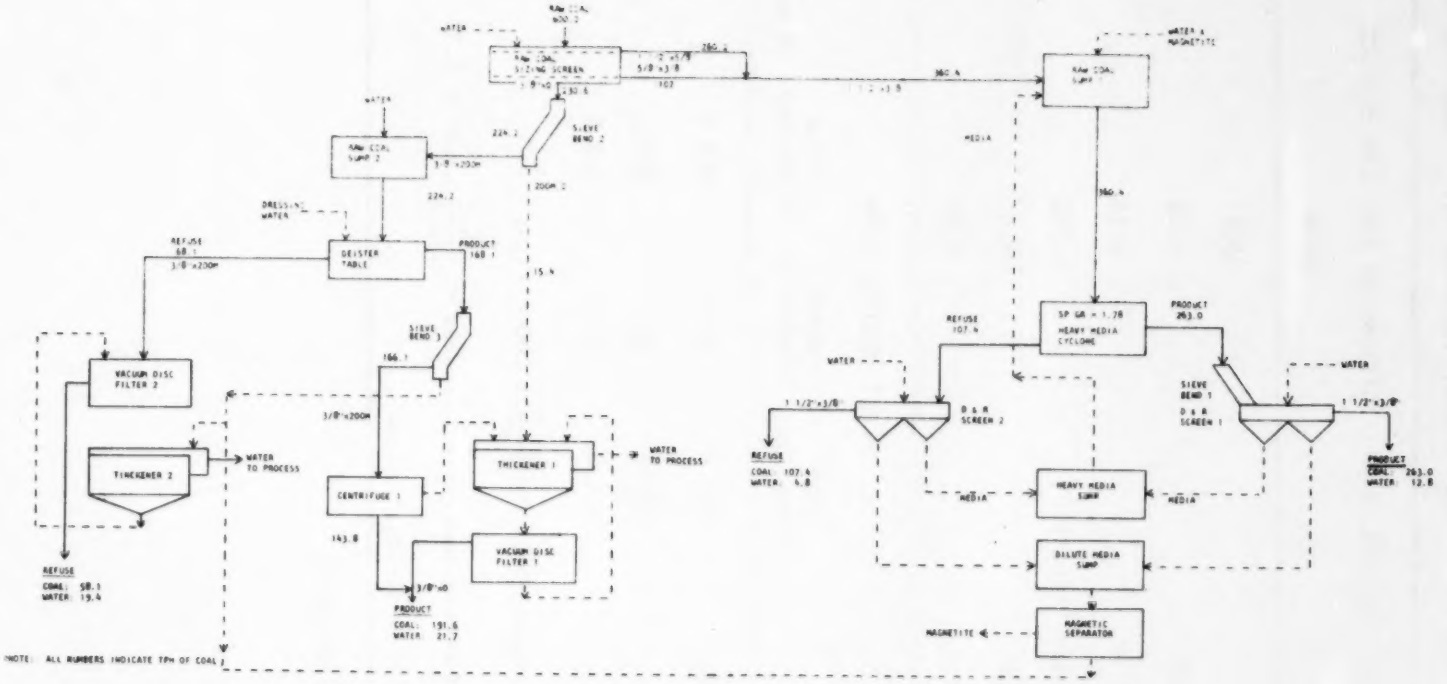

Figure 2. Steam coal preparation plant designs Illinois No. 4 seam coal, Williamson, IL[3]

TABLE 7. PRODUCT SPECIFICATION, ILLINOIS NO. 6 COAL--DESIGN NO. 9[3]

A. CHEMICAL SPECIFICATIONS OF FEED AND PRODUCT

	Feed	Product
Ash, %[a]	29.9	11.4
Total S, %[a]	4.35	3.30
Pyritic S, %[a]	3.13	1.80
Heating Value (Btu/lb)[a]	9,782	12,370
Moisture, %	8.0	7.3
Lb $SO_2/10^6$ Btu	8.89	5.34

B. PLANT PRODUCT FLOW

	Coal (tons/hr)	Water (tons/hr)	Total (tons/hr)	% moisture
1 1/2 x 3/8"	253.0	12.6	265.6	4.7
3/8" x 0	181.5	21.7	203.2	10.2
Total	434.5	34.3	468.8	7.3

Weight Yield = $\frac{434.5}{600}$ x 100 = 72.4%

Moisture Content of Product = $\frac{34.3}{468.8}$ x 100 = 7.3%

BTU Recovery = 91.6%

[a]Moisture free basis

TABLE 8. CAPITAL COSTS FOR RAW COAL STORAGE AND HANDLING (MID 1978 $)[3]

Raw Coal Storage Area (10,000 ton avg.; 20,000 ton max. capacity, stacking tube, 4 withdrawal areas, 4 reciprocating feeders of tunnel) (40 hp) =	$ 463,000
Belt Conveyor from raw coal storage to scalping tower (42 in. wide, 250 ft center to center, 60 ft elevation, 75 hp motor) $560/ft x 250 ft =	140,000
Scalping Screen (8 x 20 ft, vibrating, double deck, inclined, 2 x 25 = 50 hp motor) $30,000/1.08	28,000
Rotary Breaker (12 ft Ø x 27 ft long, $165,000/ 1.08 =	153,000
Scalping Tower, Rotary Breaker Motor (100 hp) and Hopper Chute and Rock Bin, 28,000 + 153,000 =	181,000
Belt Conveyor from Scalping Tower to Process (42 in. wide, 250 ft center to center, 60 ft elevation, 75 hp motor)	140,000
Tramp Iron Magnet (Explosion Proof, Self Cleaning)	22,000
Total Installed Cost	$1,127,000

TABLE 9. PREPARATION PLANT EQUIPMENT (MID 1978 $)
ILLINOIS NO. 6 COAL--DESIGN NO. 9

Unit	Number	Size and description	Total cost
Raw Coal Sizing Screen	2 units	7' x 20', Double Deck, Vibrating, incl., wet	50,600
Heavy Media Cyclone	4 units	26"	40,400
Diester Table	9 units	Double deck, Concenco 88 Table--Model HCPD	183,600
Sieve Bend 1	3 units	60", 7' Wide	15,600
Sieve Bend 2	3 units	30", 7' Wide	12,000
Sieve Bend 3	2 units	30", 7' Wide	8,000
Drain and Rinse Screen 1	3 units	6' x 16', Single Deck, Vibrating, horiz., wet	68,100
Drain and Rinse Screen 2	1 unit	7' x 16', Single Deck, Vibrating, horiz., wet	23,100
Centrifuge 1	3 units	Scroll tyupe, CMI--Model EB36	75,000
Filter 1	1 unit	Vacuum Disc 12' 6" Disc, 10 discs	129,600
Filter 2	3 units	Vacuum Disc 12' 6" Disc, 7 discs	388,800
Magnetic Separator	2 units	30", 10' long	19,700
Raw Coal Sump 1	8 units		80,000
Raw Coal Sump 2	2 units		20,000
Heavy Media Sump	5 units		50,000
Light Media Sump	2 units		20,000
Pumps			138,800
		Equipment cost	$1,323,300
		Freight (2% of total equipment cost)	26,500
		Total Equipment Cost (not installed)	$1,349,800

TABLE 10. CAPITAL COST FOR CLEAN COAL AND REFUSE EQUIPMENT (MID 1978 $) ILLINOIS NO. 6 COAL--DESIGN NO. 9[3]

Thickener 1 (85 ft diameter) =	$ 157,000
Thickener 2 (85 ft diameter) =	157,000
Refuse Belt (36 in. wide, 200 ft) =	104,000
Refuse Bin (2 units, each 450 ton capacity) =	162,000
Coal Sampling System =	324,000
Refuse Handling Equipment	
2 Trucks at 80,000 each =	160,000
2 Dozers at 160,000 each =	324,000
TOTAL INSTALLED COST	$1,388,000

TABLE 11. SUMMARY OF CAPITAL COSTS (MID 1978 $)
ILLINOIS NO. 6 COAL--DESIGN NO. 9[3]

Raw Coal Storage and Handling	$1,127,000	
Preparation Plant Equipment Cost 1,349,800		
Total Cost of Prep. Plant (2.35 x Prep. Plant Equipment Cost)	3,172,000	
Miscellaneous Facilities and Equipment	1,388,000	
TOTAL DIRECT COSTS		$ 5,787,000
INSTALLATION COSTS, INDIRECT		
Engineering (10% of direct costs)	569,000	
Construction and Field Expense (10% of direct costs)	569,000	
Construction Fees (10% of direct costs)	569,000	
TOTAL INDIRECT COSTS		1,707,000
CONTINGENCIES (25% of direct and indirect costs) (includes startup and performance tests)		1,849,000
TOTAL TURNKEY COSTS		9,243,000
LAND		264,000
WORKING CAPITAL (25% of direct operating costs)		571,000
GRAND TOTAL		$10,078,000

TABLE 12. ANNUALIZED COSTS (MID 1978 $) ILLINOIS NO. 6 COAL--DESIGN NO. 9[3]

Direct Labor (18 man yr x $23,700 man yr)	$ 426,600	
Supervision (2 man yr x $30,400/man yr)	60,800	
Maintenance Labor (8 man yr x $23,700/man yr)	189,600	
Maintenance Materials and Replacement Parts (% of total turnkey costs)	647,000	
Electricity (25.8 mils/kWh) (3,500 kW x 3.325 h/hr)	300,300	
Water ($0.15/$10^3$ gal x 5.6 x 10^6 gal/yr)	900	
Waste Disposal ($1/ton x 6.124 x 10^5 tons/yr)	612,400	
Chemicals (magn: 694 tons/yr x $65/ton) (floc: 0.2 tons/yr x $3,000/ton)	45,700	
TOTAL DIRECT COST		$2,283,300
Payroll (30% of direct and indirect and maintenance labor)	203,100	
Plant Overhead (26% of direct, indirect and maintenance labor and maintenance, and chemicals	356,100	
TOTAL OVERHEAD COST		559,200
Capital Recovery Factor (11.75% of Total Turnkey Costs	1,086,100	
G&A, Taxes and Insurance (4% of Total Costs)	369,700	
Interest on Working Capital (10% of W.C.)	57,100	
TOTAL CAPITAL CHARGES		1,512,900
TOTAL ANNUALIZED COSTS		$4,355,400
Cost per Ton of Moisture Free Product		$3.01
Cost per 10^6 Btu of Product		$0.122

TABLE 13. ENVIRONMENTAL FACTORS, ILLINOIS NO. 6, DESIGN NO. 9[3]

A. SOLID WASTE

	Solid (tons/hr)	Water (tons/hr)	Total (tons/hr)
From D&R Screen 2	107.4	4.9	112.3
From Disc Filter	58.1	19.4	77.5
TOTAL	165.5	24.3	189.8

Tons of Refuse (Dry Basis)/Tons of Product = $\frac{165.5}{434.5}$ = 0.381

B. WATER DISCHARGE PARAMETERS

Assume Effluene Flow Rate = 75 liters/kkg of product

Primary Pollutants		
Total Dissolved Solids	(265 g/kkg of product) =	104,434 g/hr
Total Suspended Solids	(7 g/kkg of product) =	2,759 g/hr
Total Volatile Solids	37 g/kkg of product) =	14,581 g/hr
COD	(11 g/kkg of product) =	4,335 g/hr
TOC	(1.9 g/kkg of product) =	749 g/hr
Major Elemental Pollutants		
Calcium	(8.8 g/kkg of product) =	3,468 g/hr
Magnesium	(4.2 g/kkg of product) =	1,655 g/hr
Sodium	(9.0 g/kkg of product) =	3,547 g/hr
Trace Element Pollutants		
Copper	(1.5 mg/kkg of product) =	591 mg/hr
Iron	(14 mg/kkg of product) =	5,517 mg/hr
Zinc	(3 mg/kkg of product) =	1,182 mg/hr
Manganese	(1.8 mg/kkg of product =	709 mg/hr)

TABLE 14. ENERGY FACTORS[3]

Energy loss in refuse:	2.462×10^6 Btu/ton Product (MF Basis)
Energy consumption in plant:	0.017×10^6 Btu/ton Product
Total energy consumption/ton of product =	2.479×10^6 Btu/ton Product
	or; 1,240 Btu/lb Product

Construction Schedule

Several manufacturing corporations as well as coal preparation managers were contacted and asked the following questions concerning the time required for the following construction milestones;

1. Decision that the plant is needed
2. Preliminary engineering
3. Detailed design
4. Issue bids and award contract
5. Construction
6. Shakedown and startup
7. Commercial operation.

McNally Pittsburg has built over 500 coal preparation plants and handling systems since 1921. Their contact[37] stated that they did not have any prepared literature on construction milestones but that they did have a chronology of coal preparation plants and handling systems built by McNally Pittsburg, Inc. 1921-1981, that he would send.

McNally Pittsburg only becomes involved in the construction of coal cleaning plants after the bids are issued. From this point to completion of the project is dependent on many factors including

- size of plant
- type of outside equipment necessary such as coal handling and storage equipment
- whether all the cleaning will occur inside the facility, etc.

For a plant having a capacity of approximately 500 tons/hr raw coal feed, it could take 2 to 2 1/2 years from the point at which the bids are issued to commercial operation. An additional 2 to 3 years may be required for the project participants to get to the point where they are ready to issue bids. A contact[38] at Roberts and Schaefer, another leading builder of coal preparation plants, stated the time from the issuance of bids to commercial operation of a 1000 tons/hr plant could be 18 to 24 months. For a smaller plant having a capacity of 300 tons/hr the time could be reduced to 11 months.

One preparation manager[39] stated that the total concept, from the time the decision is made that the plant is needed to commercial operation could take 5 years. Two years may be required for the plant to get through the initial permitting and design and another 2 to 3 years to complete construction. GCA sent out several letters to Preparation Managers concerning construction milestones but did not receive any responses.

The concensus of the persons contacted indicate that the time required from the initial decision that the plant is needed to commercial operation of a coal cleaning plant with a capacity of 500 tons/hr may be 5 years. Smaller plants will probably require less time.

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